

Preliminary Amendment

U.S. National Stage of PCT/US2004/031594

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Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (original) A method for three-dimensional reconstruction (3DR) of a single tubular organ using a plurality of two-dimensional images comprising:
 - displaying a first image of a vascular network;
 - receiving input for identifying on the first image a vessel of interest;
 - tracing the edges of the vessel of interest including eliminating false edges of objects visually adjacent to the vessel of interest;
 - determining substantially precise radius and densitometry values along the vessel;
 - displaying at least a second image of the vascular network;
 - receiving input for identifying on the second image the vessel of interest;
 - tracing the edges of the vessel of interest in the second image, including eliminating false edges of objects visually adjacent to the vessel of interest;
 - determining substantially precise radius and densitometry values along the vessel of interest in the second image;
 - determining a three dimensional reconstruction of the vessel of interest; and
 - determining fused area measurements along the vessel.
2. (currently amended) The method according to claim 1, wherein the vessel of interest is selected from the group ~~comprising~~ consisting of: an artery, a vein, a coronary artery, a carotid artery, a pulmonary artery, a renal artery, a hepatic artery, a femoral artery, a mesenteric artery, and any other tubular organ.
3. (original) The method according to claim 1, further comprising determining a centerline, comprising a plurality of centerline points.

4. (original) The method according to claim 1, wherein the fused area measurements are obtained using a fusion of diameter and cross section-densitometry derived measurements.

5. (currently amended) The method according to claim[[s]] 1 [[or 4]], wherein determining the fused area comprises:

determine a plurality of healthy diameters along the vessel of interest to be used as a physical reference;

normalizing a majority of the data, diameters and cross-section values to physical units, using the above physical reference; and

fusing a majority of the data into single area measurements, weighting each source of data according to the reliability of the data.

6. (original) The method according to claim 5, where weighting is computed as a function of the views geometry and/or 3D vessel geometry.

7. (currently amended) The method according to claim 1, wherein the input for identifying the vessel of interest comprises [[of]] three points: comprise a first point to mark the stenosis general location, a second point proximal to the stenosis, and a third point distal to the stenosis.

8. (currently amended) The method according to claim 1, wherein the input for identifying the vessel of interest comprises markers for two [[(2)]] points for at least one of the first and second images, wherein one of the two points is anywhere proximal to the stenosis and the other point is anywhere distal to the stenosis.

9. (currently amended) The method according to claim 1, wherein the markers comprise two [[(2)]] points for the first image and one [[(1)]] point for the second image, wherein one of the two points is anywhere proximal to the stenosis and the other point is anywhere distal to the stenosis and wherein one point is an anchor point identified automatically on the first image.

10. (original) The method according to claim 1, wherein elimination of false edges comprises ignoring one or more bubbles adjacent the vessel of interest.

11. (currently amended) The method according to claim 1 [[or 10]], wherein elimination of false edges comprises:

defining a region of interest substantially parallel to a primary centerline;

detecting at least one cluster of pixel data, adjacent to the vessel of interest, wherein each cluster of pixel data having a predetermined brightness level greater than a brightness level of surrounding pixel data;

selecting an arbitrary pixel within each cluster;

selecting a second pixel provided on a lane bounding the region of interest for each arbitrary pixel of each cluster;

establishing a barrier line to define an edge for the vessel of interest by connecting a plurality of arbitrary pixels with a corresponding second pixel, wherein upon the tracing each edge of the vessel of interest, the traced edge avoids each barrier line.

12. (original) The method according to claim 1, wherein elimination of false edges comprises detecting and/or eliminating one or more bumps along the vessel of interest.

13. (currently amended) The method according to claim 1 [[or 12]], wherein elimination of false edges includes:

establishing a list of suspect points, comprising:

establishing a plurality of first distances between each of a plurality of originating points on at least one preliminary traced edge and a corresponding closest point positioned along the primary centerline;

establishing a plurality of second distances between each of a plurality of second centerline points point on the primary centerline to a corresponding closest point positioned on the at least one edge; and

determining deviation, from the centerline, an absolute distance of the second distance and the first distance;

determining a gradient cost function, inversely proportional to a gradient magnitude at each edge point;

determining a combined function aggregating deviation from the centerline and the gradient cost function, wherein upon the combined function being greater than a

predefined value, the corresponding edge point is determined to be a bump point in a bump;

determining a bump area defined by a plurality of connected bump points and a cutting line adjacent the vessel of interest, wherein the cutting line comprises a line which substantially maximizes a ratio between the bump area and a power of a cutting line length; and

cutting the bump from the edge at the cutting line to establish a final edge.

14. (original) The method according to claim 3, wherein defining a centerline of the vessel of interest comprises:

determining final traced edges of the vessel of interest;

determining pairs of anchor points, wherein each pair comprises one point on each edge;

determining a cross-sectional line by searching for pairs of anchor points which, when connected, establish the cross-sectional line substantially orthogonal to the centerline;

dividing each edge into a plurality of segments using the anchor points, wherein for each segment, correspondence between the edges is established in that every point of each edge includes at least one pair of points on an opposite edge and a total sum of distances between adjacent points is minimal; and

connecting the centers of the plurality of segments to determine the centerline.

15. (original) The method according to claim 1, wherein determining densitometry values comprises subtracting a background influence.

16. (currently amended) The method according to claim 1 [[or 15]], wherein determining densitometry values comprises:

establishing a plurality of profile lines substantially parallel to at least one edge of the vessel of interest;

establishing a parametric grid covering the vessel of interest and a neighboring region, wherein the parametric grid includes a first parameter of the vessel of interest

along the length thereof and a second parameter for controlling a cross-wise change of the vessel of interest;

sampling the image using the grid to obtain a plurality of corresponding gray values, wherein:

the gray values are investigated as functions on the profile lines;

substantially eliminating detected occluding structures on the outside of the vessel of interest, the structures being detected as prominent minima of the parameters;

substantially eliminating prominent minima detected on the inside of the vessel of interest;

averaging gray values in a direction across the vessel of interest separately for each side of the vessel of interest;

determining a linear background estimation on the grid inside the vessel of interest; and

determining cross-sectional area using the eliminated prominent minima.

17. (original) The method according to claim 1, further comprising determining healthy vessel dimensions using an iterative regression over a healthy portion of the vessel of interest.

18. (original) The method according to claim 17, wherein each iteration comprises a compromise between a pre-defined slope and a line that follows healthy data.

Claims 19 and 20 (canceled)

21. (original) The method according to claim 3, wherein determining the three-dimensional reconstruction of the vessel of interest includes:

determining a conventional epi-polar distance p_1 for the plurality of centerline points in the first image;

determining a conventional epi-polar distance p_2 for the plurality of centerline points in the second image; and

re-determining p_2 substantially in accordance with $p_{2\text{new}} = p_2 + \delta$, where δ is a smooth compensatory function establishing correspondence of one or more landmark points.

Claims 22 and 23 (canceled)

24. (original) The method according to claim 1, further comprising displaying quantitative analysis of the vessel of interest including cross-section area graph and/or lesion analysis measurements.

Claim 25 (canceled)

26. (original) A system for three-dimensional reconstruction (3DR) of a single blood vessel using a plurality of two-dimensional images comprising:

a display for displaying a first image of a vascular network and a second image of a vascular network, and a three-dimensional reconstruction of a vessel;

input means for receiving input for identifying a vessel of interest on the first image and for identifying the vessel of interest on the second image;

a processor arranged to operate one or more application programs comprising computer instructions for:

tracing the edges of the vessel of interest including eliminating false edges of objects visually adjacent to the vessel of interest;

determining substantially precise radius and densitometry values along the vessel;

tracing the edges of the vessel of interest in the second image, including eliminating false edges of objects visually adjacent to the vessel of interest;

determining substantially precise radius and densitometry values along the vessel of interest in the second image;

determining a three dimensional reconstruction of the vessel of interest; and

determining fused area measurements along the vessel.

Claims 27-64 (canceled)